The Reichenbach-Einstein Debate on the Geometrization of the Electromagnetic Field

By: Marco Giovanelli

The 1958 English translation of Reichenbach's Philosophie der Raum-Zeit-Lehre (1928) was missing the long, technical Appendix entitled 'Weyl's Extension of Riemann's Concept of Space and the Geometrical Interpretation of Electromagnetism'. The only detailed analysis of the text was provided in the late 1970s, by Coffa, who read it exclusively as a critique of Weyl's 1918 attempt to unify gravitation and electromagnetism in a common geometrical setting. Letters between Reichenbach and Einstein suggest that the Appendix, despite its somewhat misleading title, should be read more broadly.

In the spring of 1926, Reichenbach, after making some remarks on Einstein's newly published metric-affine theory, sent him a typewritten note offering what looked like his own attempt at a unified field theory. Reichenbach's note turns out to have been an early version of 49 of the Appendix, on which he was working at the time. Einstein's objections and Reichenbach's replies reveal that criticism of Weyl's theory was only part of the story. Reichenbach intended to provide a philosophical reflection of the very notion of geometrization' in physics.

At the time, many believed that, after general relativity has geometrized the gravitational field, the obvious thing to do was to geometrize the electromagnetic field. To challenge this view, Reichenbach constructed a toy-theory establishing a connection between geometry and electricity which, he argued, was just as good as the connection that general relativity established between gravitation and geometry. Differently from general relativity, however, Reichenbach's theory did not lead to new results. Thus, Reichenbach could provide evidence that the geometrization of a physical field cannot be regarded in itself as a physical achievement. As soon as Einstein understood the ironical' nature of Reichenbach's enterprise, he immediately agreed with him. As Lehmkuhl has recently shown, it was in this correspondence with Reichenbach that Einstein pointed out, for the first time, that general relativity had not geometrized the gravitational field.

This paper suggests that the geometrization issue was not just a spin-off of Reichenbach's 1928 monograph, but possibly the core message of the book. The paper will be structured as follows:

After providing the context in which Reichenbach, in March 1926, decided to send Einstein a typescript on the geometrization of the electromagnetic field, the paper will provide a reconstruction of its content. The note shows how it is possible to concoct the general relativistic equations of motion in a way that charged particles, under the influence of an electromagnetic field, are not deflected by a force, but follow their natural path' defined by a nonsymmetric affine connection. In the latter the straightest lines (defined via parallel transport of vectors) in general do not coincide with lines of extremal length. Charged mass points of unit mass move along the straightest lines, and uncharged particles move on the straightest lines that are at the same time the shortest ones.

The paper will reconstruct the Einstein-Reichenbach correspondence of March/April 1926 concerning the note. Einstein initially reacted skeptically to what he believed to be Reichenbach's attempt to a unified field theory, raising several technical objections. In particular he pointed out that differently from the gravitational charge-to-mass ratio the electrical charge-to-mass-ratio e/m varies from particle to particle; thus Reichenbach's equations of motion are valid only for one type of particles with a characteristic value of e/m. Reichenbach defended his theory, insisting that his equations of motion are

valid for unit masses of arbitrary charge. However, he warned Einstein that he should not have read the theory as a serious physical proposal, but as a toy-theory intended to show that the geometrization of a physical field is more a matter of mathematical ingenuity than of physical insight. Reichenbach's philosophical point clearly resonated with Einstein.

The paper will show the difference between the unpublished note and its published version. In May 1926, Reichenbach gave a talk in Stuttgart based on the note, which eventually became 49 of the Appendix of Philosophie der Raum-Zeit-Lehre. As a letter to Moritz Schlick reveals the latter was already finished by the end of 1926, even if it was put into print at the end of 1927. The published 49 is for the most part identical to the note, but Reichenbach might have realized the seriousness of Einstein's objection: if one wants to have all charged particles moving on geodesics under the influence of the electromagnetic field, Reichenbach has no other way than to introduce for each value of e/m a separate affine connection.

In a four-dimensional setting the price to pay for imposing a geodesic equation of motion to describe a non-universal force is extremely high. Surprisingly, Reichenbach decided that the price was worth the message he intended to convey: The geometrical interpretation of gravitation is merely "the visual cloak" in which the gravitational field can be dressed; with some sartorial skills, one can dress' the electromagnetic field in an equally nice geometrical cloak, without reaching any physically significant result.

It was precisely this message that Einstein endorsed in his own 1928 review of Philosophie der Raum-Zeit-Lehre. After showing that this apparent convergence actually hides a somewhat complicated dialectic, the paper concludes that the Reichenbach-Einstein correspondence might be interesting from two points of views:

From a historical standpoint, the Einstein-Reichenbach debate inaugurated an important philosophical reflection about the role played by geometric considerations in physical theories. Reichenbach's 1928 monograph should be read against this background as an attempt to present general relativity as a physicalization of geometry, against the prevailing opinion that it marked the beginning of the geometrization of physics. The decision not to include the Appendix in the 1958 English translation of the book is probably the reason why this issue has been neglected, despite Einstein's endorsement. Reichenbach's toy-theory might be, however, also interesting from a systematical point of view. Pace Reichenbach, the theory shows the intrinsic limitations of any attempt to impose a geodesic equation of motion to a non-universal interaction in a four-dimensional setting. Similar attempts made around 1970s present the very same drawbacks of Reichenbach's theory.